3

THE SHORE PLATFORMS OF LORNE, VICTORIA

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Abstract

The rocks composing the almost horizontal platforms described are Jurassic sediments (arkoses, shales and mudstones) with varying angles of dip and strongly jointed. The platform chiefly dealt with, which the writer terms the 'normal platform', truncates these rocks and forms a narrow bench exposed at low tide. It consists of an upper smooth-surfaced portion (referred to in the text as the 'high-level platform') and a lower portion (similarly referred to as the 'low-level platform'). This low-level platform is divided parallel to the coast into the abrasion ramp, the depression and the rampart. Rock fans have been formed at the foot of the cliffs in association with the abrasion ramp and miniature bays. Both platforms are at present being extended landward and being destroyed at their seaward margins by marine erosion. The suggestion is made that the lower platform was originally formed similarly to the upper one, but that it has since been transformed into its present three-divisional irregular surface. There is no evidence known to the writer that both platforms have not been formed with sea-level as at present. Above the platforms are certain shelves and terraces which are being extended by marine erosion at their present levels. Some aspects of the sloping platform, which the writer terms the 'ultimate platform', and which extends seaward from the outer margin of the horizontal platforms above referred to, are also described.

Contents

INTRODUCTION
GENERAL DESCRIPTION OF THE COAST
THE ROCKS OF THE COAST
STRENGTH AND DIRECTION OF THE WAVES
THE PLATFORMS
    (1) Terminology
    (2) The Normal Platforms
        (a) General Characteristics
        (b) The Low-level Platform
            (i) The rampart
            (ii) The depression
            (iii) The abrasion ramp
            (iv) Miniature bays
            (v) Rock fans
        (c) The High-level Platform
        (d) Causes of the Difference between the Low-level and the High-level Platforms
    (3) The Ultimate Platform
SHELVES AND TERRACES ABOVE THE NORMAL PLATFORMS
REFERENCES

Introduction

Until very recently practically all geological textbooks showed, as a result of wave action, a cliff with a platform sloping indefinitely seaward from the base of the cliff. No mention was made of an upper, narrow, practically horizontal platform which occurs on many coasts, and which, at its seaward edge, passes by a sharp or gradual step to the lower sloping platform. The origin of the upper platform has been discussed by various authors, such as Douglas Johnson (1931, 1938), J. A. Bartrum (1926, 1935), A. B. Edwards (1941, 1942), and the writer (1931, 1939, 1940 and 1948). (The upper and lower platforms are in this paper referred to as the 'normal' and 'ultimate' platforms respectively.)

As Douglas Johnson (1931) has shown, the interest in the upper platform first centred on the question whether certain types were evidence of recent emergence, and that question has, for many platforms, been answered in the negative.

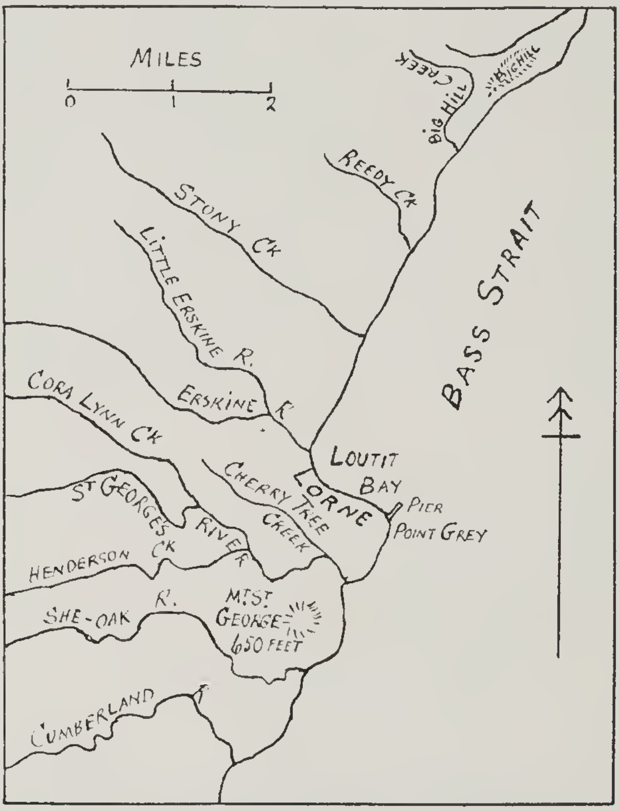


FIG. 1.—Outline map of the Lorne coast and inland country.

The chief features of interest now are the various heights in relation to mean sea-level at which the normal platforms are cut; the form and origin of their component parts; their subsequent modifications; and the process of their destruction, wholly or in part. In the case of Lorne, there are two platforms which come within the category of the writer's 'normal' platforms, and yet these platforms have strikingly different characteristics. These features form the subject matter of this matter.

The writer is not aware of any previous description of the platforms.

General Description of the Coast

Lorne is situated on Bass Strait in the Great Southern Ocean between Port Phillip Bay and Cape Otway, Victoria, Australia. The general trend of the coast is approximately north-north-east and south-south-west, and the portion dealt with in this paper extends from the Cumberland River to the Big Hill Creek, a distance of between eight and nine miles.

Loutit Bay divides the coast-line into two portions running in the same general direction but nearly a mile apart (Fig. 1). Both portions are very free from pronounced indentations, and yet are not crenulated.

The coast-line is backed by cliffs which, in some instances, attain a height of over 300 feet, although in places they are not more than 50 feet high, in which case they connect with the high steep country behind by long gentle slopes. The greater portion of the face of the cliffs is covered by a sheet of creeping detritus, carrying abundant vegetation, and with slopes usually between 30° and 40° from the horizontal. Below these portions the cliffs are bare, rocky, and practically vertical, reaching to a height of about 40 feet above sea-level, of which the best illustration occurs at the Big Hill. Overhanging cliffs are scarce, but an example occurs a little south of the mouth of the Big Hill Creek. A few cliffs have faint nips at their base (Fig. 2). There is no prominent headland except at the Big Hill.

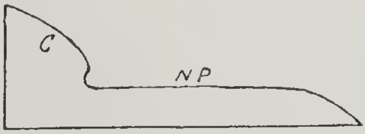


FIG. 2.—Section showing an unusual nip for a height of about three feet in the cliff (C), which is covered with vegetation above the nip. NP—Normal platform. South of Big Hill Creek.

The country which borders the coast-line is a plateau which rises to a height of over 600 feet above sea-level, and which has been dissected into deep V-shaped valleys such as those of the Big Hill, Stony and Reedy Creeks, and Sheoak, Cumberland, Erskine and St. George's Rivers, all of which have falls and rapids. Hence the topography is immature and there are no valleys with wide mouths; and hence also, if drowning of the valleys had taken place to a limited extent only, there would be no wide estuaries stretching far into the land, and such is the case.

Progradation has taken place, particularly in three areas: (1) immediately to the south-west of Point Grey, where a series of miniature bays has been partially filled by a deposit of beach sands capped by dune sands; (2) immediately to the north-east of the Erskine River, where similar phenomena occur, without, however, the prevalence of miniature bays; and (3) the extensive deposits which occur to the south and south-east of the mouth of the Erskine River, and which form the head of Loutit Bay. Those deposits may in part have been built up by detritus brought to the sea by the Erskine River, and in part by the sea bringing material from elsewhere on the coast. The old coastal cliffs, now much worn down, are traceable behind the prograded material of Loutit Bay.

Heavy shingle is not abundant along the coast except for short distances on either side of the mouths of rivers.

The shore platforms, the subject matter of this paper, stretch along the coast almost continuously, except in front of the broad, long, sandy beach to the south and south-east of the Erskine River mouth, which, for convenience, is subsequently referred to as the 'Erskine Beach' (Fig. 3).

The range of the spring tides at Lorne is 5 ft. 6 in. This information has kindly been supplied by the Ports and Harbours Branch of the Public Works Department of Victoria. No records are available as to the range of the neap tides.

The writer has not seen any direct evidence of either recent submergence or emergence in the area considered in this paper.

The Rocks of the Coast

The lithological and structural characters of the rocks of the coast and of the shore platforms must be considered.

The rocks along the whole of the coast-line dealt with are felspathic sandstones, mudstones and shales, with the sandstones greatly predominating, all of Jurassic age. The term 'sandstones' is used throughout this paper, although Edwards and Baker (1943) have shown that most of the rocks which had previously been called sandstones are really arkoses; but it is convenient for the purpose of the paper, which only incidentally touches on the geology of the district, to retain the older term. To save repetition the mudstones and shales are subsequently collectively referred to as 'shales'.

The sandstone beds vary in thickness from a few inches to four feet or more. Many are massive and tough and so resist erosion fairly well. The shales, on the other hand, are very rubbly. Numerous calcareous and ferruginous concretions, varying in form from more or less spherical to irregular elongated masses, and ranging in size from one or two inches to four feet or more, occur in the sandstones and, owing to their greater hardness, project above the enclosing rocks. Some of these concretions resemble cannon balls, and hence that name has been popularly applied to them (Pl. V, fig. 1).

The rocks dip from 2° or 3° to 45°, and their strike varies considerably, both actually and, according to the changes in direction of the coast-line, relatively to that feature.

Two sets of vertical or nearly vertical joints, mostly close to right angles with each other, and both closely and widely spaced, are well developed. The result is that a flat surface is divided into a number of rectilinear areas of various size.

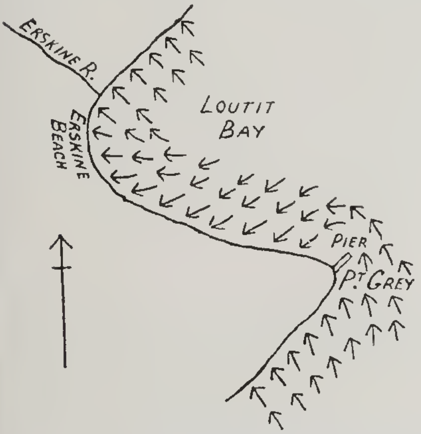
For further details of the lithology and geological structure, in addition to the paper by Edwards and Baker already cited, reference may be made to the writings of Wilkinson (1865), Krausé (1874) and Murray (1887).

Strength and Direction of the Waves

Since the coast faces Bass Strait in the Great Southern Ocean, the waves which break on the shore have a considerable fetch.

The angle at which the waves strike the shore, combined with the lithological nature and geological structure of the rocks constituting the coast, has an important bearing on the formation and modification of the platforms, and so some details of wave direction are given.

Whilst the waves are mostly normal to that portion of the coast on which they break, a pronounced exception occurs at the platform (which may be referred to as the 'Point Grey-Erskine Platform') between Point Grey and the southern end of the Erskine Beach, the direction of that platform being west-north-west. When the waves come from a southerly direction, as they usually do, they turn at Point Grey and, acquiring a south-westerly direction, strike the platform at an acute angle (Fig. 3). When also, as on comparatively rare occasions, they come from the north, they strike the same platform at an acute angle also. Some of these waves, however, swing around Point Grey and, turning rapidly, hit the coast-line south-west of that point close to the normal (Fig. 4).



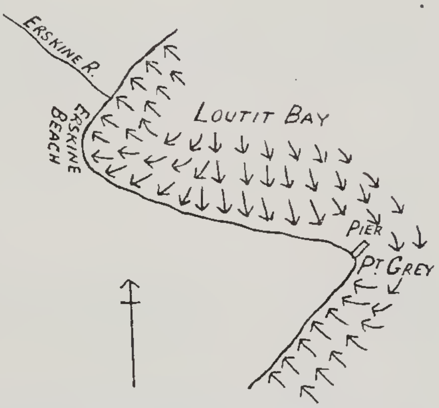


Fig. 3.—The arrows show that, when the wind is from the south, south-east or south-west, the waves are normal to the coast-line south-west of Point Grey, but at the latter point they turn into Loutit Bay and strike the Point Grey-Erskine Platform at an acute angle to the coast-line, gradually becoming more westerly towards the Erskine Beach of Loutit Bay, until they become normal to the beach and continue so to the north-east of the Erskine River mouth.

Fig. 4.—As shown by the arrows, when the wind is from the north the waves strike the Point Grey-Erskine Platform at an acute angle, and then swing around Point Grey and turn until they become normal to the coast-line south-west of Point Grey. They also swing to the normal at the Erskine Beach.

At Point Grey there is a wide isolated platform (which is subsequently referred to in this paper as the 'Point Grey Platform'). On the ocean side of that platform the waves are usually normal. They, however, curl around the platform and pass down and parallel to the opposite

(Loutit Bay) side, but at right angles (or nearly so) to the direction of the waves on the ocean side.

The Platforms

(1) TERMINOLOGY

The main platforms described in this paper are referred to as the 'normal' and 'ultimate' platforms, following the terminology of the writer in his papers on the platforms of Sydney (1939), Mt. Martha (1940) and Flinders (1948).

A. B. Edwards (1941) has criticised that terminology, pointing out that Fenneman (1902) had applied the word 'normal' to the platform which corresponds to the writer's 'ultimate' platform. Fenneman's term, however, is the 'normal profile of equilibrium,' which covers more than the erosion-formed platform. The writer does not now intend to enter into a discussion of the matter. He considers that both platforms are the normal result of marine erosion, and hence both might be termed 'normal'. Until more appropriate names are found the writer proposes to keep to those already used by him; and so long as the platforms described are clearly identified, the want of suitable terms is not of serious consequence.

(2) THE NORMAL PLATFORMS

(a) GENERAL CHARACTERISTICS

Along the coast-line referred to in this paper the platforms (extending seaward from the foot of the cliff and terminating by a drop to the ultimate platform) are practically horizontal. They are fairly continuous (even passing across the mouths of the streams of the district) with the exception of an extensive break at the prograded area of Loutit Bay. As the mouths of the streams and the miniature bays referred to below are approached, the platforms have a slight fall parallel to the coast-line (Fig. 5). Thus the bottoms of the river-mouths and of the miniature bays form local base-levels of erosion to which the platforms by atmospheric and marine erosion, acting parallel to the coast-line, tend to be reduced.

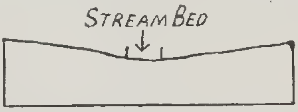


FIG. 5.—Section parallel to the coast-line across the mouth of a stream cutting across the normal platform. It shows the fall of the platform on each side of the stream bed. Stony, Reedy and Big Hill Creeks.

The platforms have an average width of about 2 chains with the exception of the Point Grey one, which has the abnormal width of about 13 chains. They are exposed at low tide; and in calm weather they are (so far as the writer's limited observations go) mostly not completely covered, unless there is a high spring tide. When great waves, raised by the wind, occur the platforms and some of the ledges above them are covered, since those features show indubitable evidence (notching, absence of atmospheric detritus, and occurrence of marine organisms), of the action of the sea at its present level.

The platforms are probably above mean high-tide level, but sufficient observations have not been made to determine that point. Probably also, even the platforms subsequently referred to as low-level ones are at slightly different levels.

The cliffs abutting the platforms carry talus and vegetation from a height of six or seven feet above the platforms. To that height the cliffs are bare, although of sufficient slope to carry vegetation and talus, which by their absence indicate that the sea acts to a height of at least six or seven feet above the platforms. (The cliffs just referred to must not be confused with the vertical cliffs that rise up to 40 feet above the normal platforms (Fig. 6).)

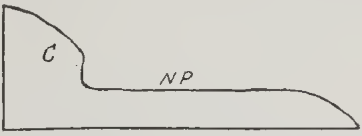


Fig. 6.—Section showing the general type of cliff, covered with vegetation in the upper sloping part, and with bare rock exposed in the lower vertical portion, which varies in height from 4 to about 40 feet. C—Cliff. NP—Normal platform.

The dip of the rocks, although very low in places, is yet practically always high enough to permit truncation of the strata; and so the harder beds tend to project above the general surface of the platforms (Pl. V, fig. 2).

Minor platforms a few yards square are found sunk in the platforms.

The normal platforms may be divided into a low-level and a high-level one.

(b) The Low-level Platform

The most characteristic portions of this platform extend from the Erskine River to Stony Creek, and from the southern end of the Erskine Beach to the Cumberland River. The platform has five main features: (i) the rampart, (ii) the depression, (iii) the abrasion ramp, (iv) miniature bays, (v) rock fans.

The rampart, the depression and the abrasion ramp are divisions of the platform parallel to the coast-line and to one another. They extend, in the order mentioned, from the ultimate platform to the cliffs.

(i) *The Rampart* (Pl. V, fig. 3) is from one to four feet, on the average, above the depression, from which, as a rule, it rises steeply (Figs. 9 and 11). The surface is usually irregular, owing to the tendency of the waves (by a process which may be termed 'quarrying') to cut channels or miniature bays through the rock mass (Pl. VI, fig. 1), which also brings about a discontinuity in the rampart (Fig. 7). Pitting, by spray action, also occurs on the surface, which is further reduced by the sea forming grooves along the bedding and joint planes.

The inner (landward) side of the rampart is frequently undermined owing to the action of the sea in traversing the depression (Pl. V, fig. 3). The outward (seaward) side drops to the ultimate platform, either steeply or with a gradual slope (Figs. 8-11).

Level platforms of a few square yards occur in the rampart above the general level of the depression.

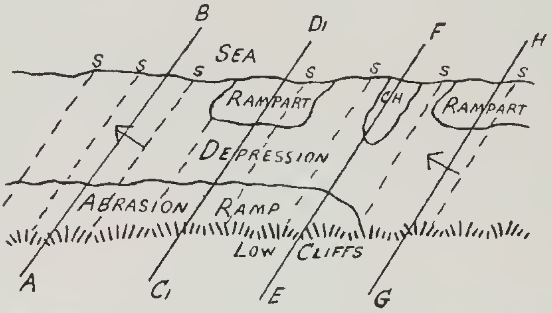
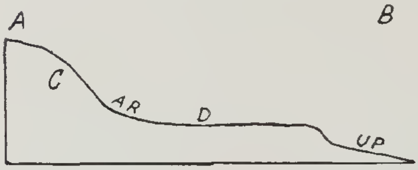


Fig. 7.—Plan of portion of the Point Grey-Erskine Platform (a low-level normal platform), showing the low cliffs, the abrasion ramp (absent in some parts), the depression, the rampart (absent in some parts), and the formation of a channel along the strike of the rocks. S—Direction of the strike of the rocks. CH—Channel cut by the waves along the strike of the rocks. AB, $C_1 D_1$, EF and GH—Sections along the strike of the rocks. The arrow indicates the direction of the dip of the rocks.



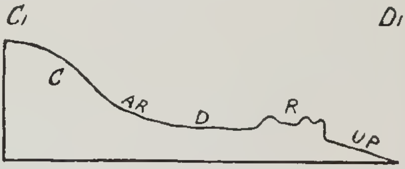
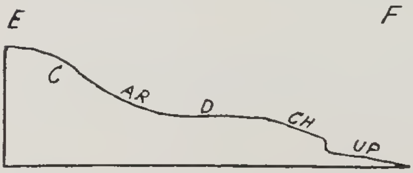


Fig. 8.—Section AB of Fig. 7 along the strike of the rocks. C—Low cliff. AR—Abrasion ramp. D—Depression. (The outer rampart is missing, so that the abrasion ramp and the depression form the normal platform.) UP—Ultimate platform.

Fig. 9.—Section $C_1 D_1$ of Fig. 7 along the strike of the rocks. C—Low cliff. AR—Abrasion ramp. D—Depression. R—Rampart. (The abrasion ramp, depression and rampart form the normal platform). UP—Ultimate platform.



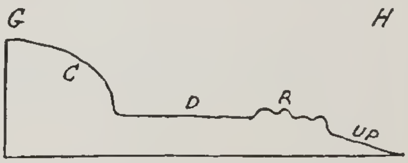


Fig. 10.—Section EF of Fig. 7 along the strike of the rocks. C—Low cliff. AR—Abrasion ramp. D—Depression. (The rampart is missing, so that the abrasion ramp and the depression form the normal platform.) CH—Bed of the channel cut in the normal platform. UP—Ultimate platform.

Fig. 11.—Section GH of Fig. 7 along the line of strike of the rocks. The abrasion ramp is missing. C—Low cliff. D—Depression. R—Rampart. UP—Ultimate platform.

(ii) *The Depression* (Figs. 8-11). This middle area is almost horizontal (Pl. V, fig. 3). Its surface is divided into rectilinear spaces of various size by strong vertical or nearly vertical joints and these areas are, in places, further broken by minor irregular joints (Fig. 12). In some instances, on each side of a joint for an inch or two, the rock has been hardened by the introduction of oxide of iron, resulting, by the more rapid erosion of the unaltered portions than of the altered, in the formation of shallow saucer-like hollows (the diameters of which may reach eight to ten feet) in which sea or rain water may lodge, forming pools usually about one inch deep but which may reach six inches (Pl. V, fig. 3). These hollows carry, in places and at different times, films of sand, small pebbles and some marine shells. Occasionally, however, a heavy temporary deposit of sand almost obscures all these features.

The surface of the depression is broken in places by narrow channels excavated mainly along the joints (Fig. 10) and by small residuals a few square feet in area and two to three feet in height.

The features described are almost wholly restricted to the sandstones.

The depression is being extended by the waves, after they break over or through the rampart, or pass into the miniature bays and spread out as lateral waves, eroding parallel to the shore. Where two miniature bays are close to each other, the lateral waves from one bay will meet and cross those from the other bay. They lose much of their original strength, and yet they seem to have sufficient power, aided by sand and small pebbles, to plane the surface evenly down, or to act as one of the factors in the reduction of that surface. They undermine the rocks on the seaward side of the depression, and so widen the latter and reduce the width of the rampart (Pl. VI, fig. 2). This is clearly illustrated where the dip of the rocks is seaward (Pl. V, fig. 3).

The direct planing action of the waves is assisted by the pitting of the rocks by the spray of the waves; by the grooving by the sea along joint and stratification planes; and doubtless by the wetting and drying (or part drying) of the surface when exposed at low tide, aided perhaps by the crystallization of the salt left by the evaporation of sea water in pits and other hollows.

Wentworth's water-levelling process (1938) may have helped to decrease the depth of the saucer-shaped hollows.

The formation or deepening of the depression is hastened where its component rocks are less resistant to erosion than those of the outer area, but nevertheless the depression forms where the rocks strike at more or less of a right angle to the shore line, as at a point 200 or 300 yards south-west of Point Grey, where a massive band of sandstone runs at a sharp angle from the shore. The outer part projects as a rampart, but behind the latter the band has been reduced to the general level of the depression, which is two to three feet below the general level of the rampart. On one side of the band a deep narrow channel, parallel to the strike of the rocks, has been cut in shales, and it is apparently from that channel that erosion of the hard band across its middle portion has taken place, so as to make that portion part of the depression.

In the Point Grey-Erskine Platform the rocks strike at an acute angle to the shore, and behind the rampart the depression is practically continuous, showing that along the same rock bands there has been greater erosion along the line of the depression than along the rampart, despite the fact that the latter receives the full frontal attack of the sea (Pl. VI, fig. 2). In this connection, Johnson (1938) has observed, in places visited by him, the erosive action of sheets of wave-derived water sweeping laterally along the beach.

(iii) *The Abrasion Ramp,* where not broken into rock fans, slopes evenly downward from the foot of the cliff at an angle of from 3° to 8° from the horizontal, and, as a rule, merges gradually into the depression (Figs. 7-10). The ramp's width varies from a few feet to about 40 feet, but just south-west of Point Grey the width is abnormal, about 70 feet. Like the depression, it has the appearance of having been steadily planed over its whole area by waves, giving a very smooth surface. There are few channels cut through it, but it has in places small residuals rising to three or four feet above its general level. The ramp, like the depression, has rectilinear vertical or nearly vertical joints, but it has not the pronounced saucer-shaped hollows of that feature, other than incipiently. Pits are scarce and very little water lodges on the ramp owing to its definite seaward fall.

Like on the depression, sand and small pebbles occur sparingly on the ramp; and the minor agents of erosion of the depression also work in the same way in the reduction of its surface.

Owing to the formation of rock fans, the seaward edge of the abrasion ramp is usually a sinuous line, and the ramp tends to be narrower at the heads of the miniature bays, owing to the greater erosion there; but this is offset, in places, by the more rapid retreat of the cliffs at the bay heads than those at the inter-bay areas.

Since the abrasion ramp grows landward coincidently with the retreat of the cliffs, and is contemporaneously destroyed on its seaward side, its indefinite widening is restricted.

(iv) *Miniature bays,* which are from two to ten feet deep, according to the distance from the coast-line, and which are probably on the average about one to two chains wide and long, are developed in the platform by the cutting by the waves through the rampart and the depression (Pl. VI, fig. 1). The result is that the abrasion ramp persists (although reduced to some extent), but parts of the depression and the rampart are removed and their places are taken by an extension landward of the ultimate platform, with its steady slope seaward from the coast-line, in marked contrast with the intervening portions of the normal low-level platform. Thus, although the abrasion ramp is usually a continuous feature, with a sinuous seaward line, it may belong to either the normal or the ultimate platform.

Where the strike of the rocks is at a substantial angle to the coast-line, the bays develop in the softer bands along the strike, and thus tend to be rectilinear in outline, as is well seen in the Point Grey-Erskine Platform.

The bottoms of the bays are exposed only at low tide, and in many places are very rough and irregular, due to the quarrying (vertical) action of the waves as contrasted with the planing (lateral) action of the waves on the depression and the abrasion ramp.

Sand beaches, usually narrow and with comparatively little sand, are found at the heads of some of the bays.

(v) *Rock Fans.* The best examples of the feature which the writer has termed a 'rock fan' occur between Point Grey and the mouth of the St. George's River; to the south-west of the mouth of Stony Creek; and to the south-west of the mouth of Big Hill Creek.

A rock fan is part of the abrasion ramp and lies between two of the miniature bays. It is usually a smooth-surfaced rock-mass, the base of which is coincident with the foot of the cliff; and from the middle of that base, the surface slopes downward in all directions possible from the foot of the cliff. The surface appears to be convex upwards.

The areas of rock fans vary considerably. Most are about the same length in their longitudinal and transverse sections. In actual size, they vary from less than one to over three chains in both sections, but the majority would probably be about one chain. One large fan south-west of the Big Hill Creek mouth is about four chains in length longitudinally.

The fans are, in places, fairly evenly spaced, in others unequally. In four examples occurring to the south-west of the mouth of Stony Creek the distance between crest and crest is from three to four chains. The height between the lowest and highest portions of a fan on the average is not more than 12 to 18 inches.

Small low residuals occur on some of the fans.

A fan may be wholly or partly destroyed by a miniature bay being so deeply cut into the shore-line that the steady connecting slope is lost.

The fans doubtless have been formed contemporaneously with the abrasion ramp. They appear to be due primarily to the formation of the miniature bays which penetrate the rampart, the depression, and, to a certain extent, the abrasion ramp. The bay areas receive the full force of the waves, often in a concentrated form, so that those areas deepen rapidly contrasted with the inter-bay areas, which receive the waves broken at the rampart, and also the diverted lateral waves from the bays; and since an inter-bay portion of the abrasion ramp is attacked from both sides and from the front by these minor waves, a rock fan is developed. The generally smooth surface of the fan indicates its formation by steady planation.

(c) THE HIGH-LEVEL PLATFORM

This platform commences just north-east of the Stony Creek mouth, and thence runs disconnectedly north-easterly for some distance; but its most characteristic portion and that which is specifically referred to in this paper extends from the commencing point for about a quarter of a mile. It is from about two to four feet above the depression of the low-level platform and about two chains wide.

Its special feature is a practically unbroken, mostly smooth surface, carrying but little detritus, and with ramparts, abrasion ramps, miniature bays and rock fans mostly absent (Pl. VI, fig. 3; Pl. VII, fig. 1). A low rampart, however, occasionally occurs (Pl. VII, fig. 2). The abrasion ramp, where present, is, on the average, about 20 feet wide.

The high-level platform has saucer-shaped hollows in sandstone rectilinear areas, which may carry temporary shallow pools of water (Pl. VI, fig. 3) similar to those occurring on the low-level platform. Pitting also occurs in the sandstones, but sparingly.

The cliffs rising from the landward edge of the platform are being attacked by the sea (Pl. VII, fig. 1), as shown by the contour of their lower portions, and by the occurrence of living mollusca and thrown-up kelp on the face of the cliff or its shelves. The landward edge of the platform is therefore retreating. Similarly the seaward edge, where it drops to the ultimate platform, is also retreating.

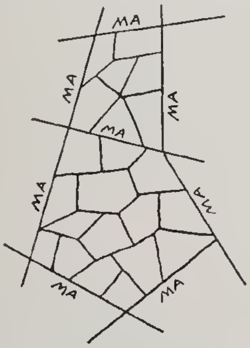
(d) CAUSES OF THE DIFFERENCE OF FORM IN THE LOW-LEVEL AND HIGH-LEVEL PLAFFORMS

The differences between the two types of normal platform—the 'low-level' and the 'high-level'—as noted in the preceding portions of this paper, are marked and call for an explanation.

In geological structure and lithological contents, the two platforms appear to be the same. It is possible that on very close examination some differences in both or either of these respects may be found, but it is questionable whether they would be great enough to cause the existing disparity in form between the two platforms. An examination of the forces of marine erosion at present at work on both platforms shows that whilst at their seaward edges both are being attacked by quarrying action, nevertheless in the case of the high-level platform the work by that method is not sufficiently advanced to have broken the platform into many miniature bays, with the result that general planation over its whole surface, aided by pitting and grooving, is the way by which the platform is being extended landward, and is no doubt being reduced vertically. An occasional miniature bay, however, occurs here and there in the platform; and, as a result, marine erosion is taking place—at present in a very limited way—behind the seaward portion of the platform parallel to the shore-line, thus indicating a tendency to produce the rampart, the depression and, to some extent, the abrasion ramp characteristic of the low-level platform (Pl. VII, fig. 2). The formation of the incipient depression has been largely helped by the fact that in the most pronounced case (which occurs a short distance north-east of the mouth of Stony Creek), shales underlie massive sandstones at about a chain from the seaward edge of the platform. That fact has greatly facilitated the reduction of the platform along the strike of the shales, which at that point is approximately parallel to the coast-line (Pl. VII, fig. 3). Another example is found on the same portion of the platform (Pl. VII, fig. 2).

It is therefore suggested that the low-level platform was originally similar in height and characteristics to the high-level one; but that, owing to the more rapid action of the sea in forming miniature bays and channels in what is now the low-level platform, that platform received its three-fold division of abrasion ramp, depression and rampart. It is difficult, however, to understand why one portion (the present high-level) of the platform should remain almost intact, whilst the other portion (the present low-level) has sustained pronounced changes. On the other hand, it is difficult to imagine how the low-level platform could be formed with its present features unless derived from an earlier, higher, smooth-surfaced one; and in support of that idea, a beginning has been made, as noticed above, in the conversion of the high-level to the low-level type.

The question arises, does the high-level platform indicate recent emergence for a few feet vertically? That question cannot be answered definitely in the affirmative, because it is clear that, at its present level in regard to the sea, it is still in course of formation. It is, however, quite possible that it was formed when the sea stood at a slightly higher level than it does now, and that the emergence has not been of sufficient magnitude to prevent the continuance of growth of the platform. If there has been emergence, then it would appear that the low-level platform also shared in that emergence, but probably when it was smooth and continuous with the high-level platform, and that, since the emergence, the low-level platform has been brought to its present three-divisioned state.



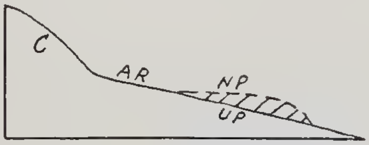


Fig. 12.—Generalized plan of an area on the normal platform bounded by major vertical joints (MA) and subdivided by numerous minor joints.

Fig. 13.—Section showing the cliff (C), the abrasion ramp (AR) and its continuance seaward as the ultimate platform, UP. The platform was originally a normal platform (NP), but it has been changed into the ultimate platform by removal by the sea of the hatched portion of the figure. Note that by this change the abrasion ramp becomes portion of the ultimate platform.

Independent evidence for emergence should be obtained in the vicinity, but the writer is not aware of any conclusive facts on the point. In the river valleys so far as examined by him there is no evidence, in the shape of river terraces, of recent emergence, and the vegetated cliffs are not necessarily indicative of that emergence. The cliffs are hundreds of feet high, and the rocks composing them are, in the main, hard, so that the advance of the platforms by marine erosion has apparently been slow compared with the more rapid atmospheric wasting of the cliffs. Progradation has been noted in various places, as already mentioned, but none of the facts pertaining to that process supports the idea of recent emergence.

If, as appears to be so, there is a gentle fall of the high-level platform to the north-east from its most characteristic portion just north-east of the Stony Creek mouth, that may indicate slight recent warping of the platform, which would probably facilitate its preservation at the highest part of the warp. That question, however, awaits further investigation.

(3) THE ULTIMATE PLATFORM

Since this platform is open to observation for a few yards only at the seaward edge of the normal platform, and even in the miniature bays, the information concerning it is scanty. It offers a marked contrast with the normal platform in that it has a definite slope seaward, whilst the normal platform is almost horizontal (Fig. 13).

In its outer part the ultimate platform doubtless has sediments deposited on its surface and so becomes a platform partly of sedimentation and partly of erosion, thus agreeing with the 'normal profile of equilibrium' of Fenneman (1902).

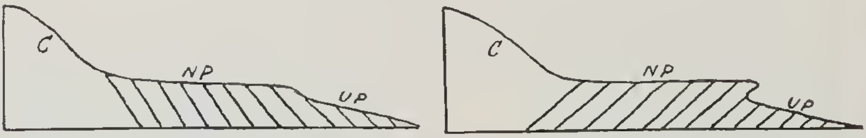


FIG. 14.—Section showing the influence in some instances of the dip of the rocks seaward on the form of the connection between the normal and ultimate platforms. C—Cliff. NP—Normal platform. UP—Ultimate platform. The lines of the hatched area indicate the direction of dip. North of Stony Creek.

FIG. 15.—Section showing the influence in some instances of the dip landward of the rocks with hard bands on the form of the connection between the normal and ultimate platforms. C—Cliff. NP—Normal platform. UP—Ultimate platform. The lines of the hatched area indicate the direction of dip. Between Point Grey and St. George's River.

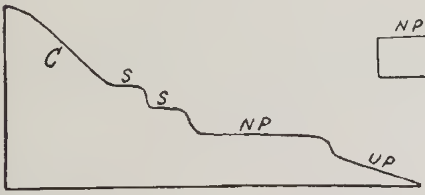
The normal platform passes downward to the ultimate platform, either sharply or gradually, and the height of the drop from the former to the latter is usually from four to ten feet. Where the dip of the rocks is seaward or the reverse, at a moderate angle, it is reflected in the direction of the connecting slope (Figs. 14 and 15).

The usually rough bottoms of the miniature bays described above are portions of the ultimate platform, so that in those instances that platform extends to the shore-line.

In the writer's paper (1940) on the Mt. Martha platforms the ultimate platform was divided into a primary platform and a secondary platform, according to whether it had originated with its present seaward slope, or to whether the normal platform was first formed and subsequently gave place to the ultimate platform by the ceaseless gnawing away of the normal platform's seaward face. At Lorne the ultimate platform appears to be of secondary origin.

Shelves and Terraces Above the Normal Platforms

These are scarce, but a few occur up to about 12 feet above the normal platforms, at which height they are being extended by the spray and by high waves. The best developed ones occur between the mouths of the St. George's and Sheoak Rivers, where they form the tops of small rectilinear masses of rock which mostly project from the cliffs for 15 to 40 feet; are from 10 to 30 feet wide; rise about 10 feet above the normal platform; dip seaward at various angles up to 40°; and are separated from one another by narrow gulches and channels, the sides of which are approximately parallel to one another, and are mostly composed of the strong vertical joint planes running more or less at right angles to the coast-line (Figs. 16 and 17). The component rocks are tough sandstones which strongly resist erosion, with the result that only small portions of the normal platform are developed. Some minor benches have also been cut below the tops of and within the projecting masses.



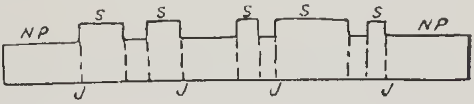


FIG. 16.—Section showing the formation of two narrow shelves (S), one five feet above the other and the lower one five feet above the normal platform (NP). C—Cliff. Both shelves have been formed by marine erosion. UP—Ultimate platform. About 300 yards south of the mouth of Sheoak River.

FIG. 17.—Section parallel to the coast-line showing shelves (S) rising six to eight feet above the normal platform (NP) at the foot of the cliffs. The rectilinear character of these shelves is owing to the prevalence of vertical joints (J) running approximately at right angles to the cliff face. Between St. George's and Sheoak Rivers.

Another group of shelves (or perhaps, in this instance, terraces would be a better name for them) occurs at the great headland at the foot of Big Hill, which is the only really outstanding headland of that portion of the coast covered by this paper. The terraces consist of benches (probably two, but this is not certain, since the writer is speaking now from memory only) each of which is but a few square yards in area, rising one above the other by 'cliffs' two or three feet high, from either side of the headland, to a crowning bench, which is the most prominent point of the headland, and which is from 10 to 15 feet wide and projects from the cliff about 20 to 30 feet at a height of about 7 feet from the normal platform. The terraces have been created by the frontal and lateral attack of the waves.

Above the shelves referred to, detritus, resulting entirely from atmospheric agents, accumulates, being unable wholly to be removed by the wind and the rain; whereas at and below the level of the shelves there is no detritus (except where there has been a recent rock fall), thus showing that the sea is eroding up to that height.

References

Bartrum, J. A., 1926. Abnormal Shore Platforms. *Jour. Geol.,* 34, 793-806.

———, 1935. Shore Platforms. *Rept. Aust. New Zeal. Assoc. Adv. Sci.,* 22, 135-143.

Edwards, A. B., and Baker, G., 1943. Jurassic Arkose in Southern Victoria. *Proc. Roy. Soc. Vic.,* n.s., lv (2), pp. 195-228.

Edwards, A. B., 1941. Storm-Wave Platforms. *Jour. Geomorph.,* 4, 223-236.

———, 1942. The San Remo Peninsula. *Proc. Roy. Soc. Vic.,* n.s., liv (1), pp. 59-74.

Fenneman, N., 1902. Development of the Profile of Equilibrium of the Subaqueous Shore Terrace. *Jour. Geol.,* 10, 1-32.

Johnson, Douglas, 1931. Supposed two-metre eustatic bench of the Pacific shores. *Comptes Rendus du Congrès International de Géographie,* Paris. Tome ii, pp. 1-6.

———, 1938. Discussion on C. K. Wentworth's water-levelling paper. *Jour. Geomorph.,* Vol. 1, p. 27.

Jutson, J. T., 1931. Erosion and Sedimentation in Port Phillip Bay, Victoria. *Proc. Roy. Soc. Vic.,* n.s., xliii (2), pp. 147-149. ..

———, 1939. Shore Platforms near Sydney, New South Wales. *Jour. Geomorph.,* 2, 237-250.

———, 1940. The Shore Platforms of Mt. Martha, Port Phillip Bay, Victoria, Australia. *Proc. Roy. Soc. Vic.,* n.s., lii (1), pp. 164-174.

———, 1948. The Shore Platforms of Flinders, Victoria, Australia. *Proc. Roy. Soc. Vic.,* n.s., lx.

Krausé, F. M., 1874. Report on Cape Otway. *Geol. Surv. Vic.,* Report of Progress, 1, Appendix A, pp. 99-109.

Murray, R. A. F., 1887. *Victoria, Geology and Physical Geography* (Government Printer, Melbourne), pp. 90-91.

Wentworth, C. K., 1938. Marine Bench-Forming Processes: Water-level Weathering. *Jour. Geomorph.,* 1, 6-32.

Wilkinson, C. S., 1865. Report on the Cape Otway Country. Papers presented to Parliament [Victoria]. Session 1864-5.

Descriptions of Plates

Plate V

Fig. 1.—The low-level normal platform of sandstone with concretions of indurated sandstone which have resisted erosion more than the main mass. In the low cliffs are cavities which formerly contained similar concretions. These cavities are scoured by the sea to a height of five feet above the platform. North-east of the mouth of the St. George's River.

Fig. 2.—The low-level normal platform, with unreduced portions of hard strata projecting up to about three feet above the general surface and dipping seaward. About 200 yards south-west of the mouth of Sheoak River.

Fig. 3.—The low-level normal platform, showing at its seaward portion a low rampart with the rocks of that feature dipping seaward at a low angle and being undermined from their landward side. There is little detritus on the platform. Looking south-easterly from about half a mile north-west of the Erskine River mouth.

Plate VI

Fig. 1.—The low-level normal platform which, owing to marine erosion, is now penetrated by numerous channels. About a quarter of a mile north-east from the mouth of the Erskine River.

Fig. 2.—The low-level normal platform, showing the smooth unbroken depression and the rampart (abutting the sea) which has been much broken by marine erosion along the strike of the rocks (at a high angle to the shoreline). The platform carries detritus at times, but at other times is almost swept free of it. Point Grey-Erskine Platform.

Fig. 3.—The smooth surface of the high-level normal platform, showing its division into rectilinear areas bounded by vertical or nearly vertical joints. Note the slightly raised strips along the joints owing to the induration of the rocks (sandstones) by iron oxide, and the absence of detritus. North of the mouth of Stony Creek.

PLATE VII

Fig. 1.—The high-level normal platform, showing its very smooth surface practically free from detritus. The base of the cliff is being attacked by the sea. Just north of the mouth of Stony Creek.

Fig. 2.—Looking north-eastward across the high-level normal platform, showing in the foreground and middle distance the smooth inner portion, broken only by some resistant bands of sandstone dipping seaward, and in the background a rampart rising two to three feet above the inner portion. The rocks of the rampart dip seaward. Between Stony and Reedy Creeks.

Fig. 3.—The high-level normal platform, looking northward. The main portion (on the right) is composed of sandstones dipping slightly seaward. The narrow strip in the middle below the level of the sandstones is composed of shales which dip conformably below the sandstones. The upper portion of the shales has been removed by the sea working southward from a small bay at the north end of the platform, thus illustrating how a depression and a rampart can be formed. Some of the boulders at the foot of the cliff have been thrown from the cliff when the coastal road was made. North of the mouth of Stony Creek.